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Measurement scale effects on spatial characteristics

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Blöschl and Sivapalan (1995) introduced the concept of a measurement scale triplet, i.e., spacing, extent and support of the measurements, relative to the true correlation length of the variable of interest. Spacing and extent are closely related through the number of samples. For spatially correlated variables, the measurement scale will affect estimates of spatial characteristics of the variable. These characteristics are typically parametric or non-parametric estimates of mean, variance and correlation length. The aim of the estimates can be either to characterise the ergodic distribution of the variable (the measured values are just one possible realisation of the random process) or to estimate the nonergodic distribution (the characteristics of the actual realisation of the variable). We have examined how the measurement scales influence non-parametric estimates of mean, variance and integral scale, and weighted least squares, maximum likelihood and restricted maximum likelihood estimates of a variogram model.

The results indicate that estimates of the mean are unbiased in all cases. For the ergodic case, the estimation error is large for small extent and decrease with increasing spacing, while it increases with increasing spacing for the realisation mean. The realisation mean will be perfectly estimated when the support is such that the measurements cover the extent exactly, and increase for smaller and larger supports.

Estimates of the variance in the ergodic case will be underestimated for small extent and for large support. The realisation variance will on the other hand be unbiased for all combinations of spacing and extent, while still underestimated for high support.

The correlation scale will in the ergodic case be underestimated for small extent, while it will be overestimated for large spacing and large support. The realisation correlation scale will be overestimated for large spacing and large support. For a small number

of samples, the non-parametric estimate of integral scale is purely a function of the measurement scale.

The estimates have been compared with analytical expectations in the ergodic cases from Western and Blöschl (1999). The non-parametric estimates are mostly following these expectations. The parametric estimates are generally less biased than the non-parametric estimates, but the uncertainty is higher. This uncertainty increases with increasing number of parameters to be fitted.

Blöschl, G. and Sivapalan, M., 1995. Scale issues in hydrological modelling - a review. Hydrological processes, 9(3-4): 251-290.

Western, A.W. and Blöschl, G., 1999. On the spatial scaling of soil moisture. Journal of Hydrology, 217: 203-224.